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FINAL TECHNICAL REPORT FOR THE AURORAL PARTICLES EXPERIMENT

ON ATS-6

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FINAL TECHNICAL REPORT FOR THE AURORAL PARTICLES EXPERIMENT ON ATS-6

1.0 SUMMARY AND ABSTRACT

During the performance of this contract, an instrument for the detection of particles in the energy range of 0.1 ev to 80 Kev was designed, built, tested, calibrated, and flown on board the geosynchronous spacecraft ATS-6. Data from this instrument has generated a wide variety of scientific investigations. A list of papers and oral presentations which use this data is given in the appendix B.

The general areas of research using this data are:

1. Intensive studies of the plasma in the vicinity of the spacecraft (e.g., occurrence of plasma waves)

2. Global variations of plasmas (e.g., plasma injections and substorms)

3. Correlative studies using either other spacecraft or ground based measurements (e.g., study of particle precipitation using ATS and ground based scanning photometers)

4. Studies of spacecraft interactions with ambient plasmas including:

    a. Charging

    b. Local electric fields due to differential charging

    c. Active control of spacecraft potential

Examples of each of these types of studies can be found in the publication list. Even though the instrument has now ceased functioning, the data is still being actively studied both by investigators at UCSD and at a number of other institutions. Also in the appendix is a list of requests that we have had for copies of the data. We always honor such requests to the best of our ability, and many of them have led to successful studies. At the present time, we have four graduate students working on these projects using this instrument.

The UCSD Auroral Particles Experiment has proven to be

extremely successful at extending our knowledge of the geosynchronous environment. Included among the new UCSD observations are:

1. Intense field aligned electron beams associated with local substorm activity and possibly auroral arcs

2. A persistent field aligned native to low to moderate energy ions, a phenomena which hints at an ionospheric source

3. Plasmaspheric particles in the bulge region of the near magnetosphere with temperatures much higher than expected

4. Field line ion bounce dispersion association with sub-storm activity

5. PC-1 wave activity previously unobserved in particle data, and

6. Unusual spacecraft charging phenomena including differential charging and non-monotonic radial charging phenomena.

The original environmental measurement program called for the operation of the Environmental Measurement Experiment (EME) for a period of two years. Many of the phenomena listed above are single satellite observations observed during that two year period and required no further data gathering for their continued study. However, the operation of the ATS-6 EME package was extended into a third year for a number of important reasons. UCSD interest in this extension included:

1. The desire to continue the study of spacecraft charging by attempting to actively control the spacecraft potential during an eclipse period using an on-board electron emitter

2. The desire to perform an unprecedented two satellite experiment with highly similar plasma instruments when the ATS-6 satellite was brought back from its eastern location past the ATS-5 western location, and

3. The desire to participate in the opening stages of the International Magnetospheric Study (IMS) where because of delays in the launch of the European GEOS project, ATS-6 was the only satellite available during these opening stages to make magnetospheric measurements and to participate in conjugate correlative studies.

The above stated projects have proceeded as planned, and much of the associated data has been collected. Some is still being analyzed.

In 1976, ATS-6 continued to gather eclipse data, and began neutralizer operations. Results from these operations indicate that the neutralizer is capable of maintaining the spacecraft potential at low values during the transitions into eclipse.

These operations demonstrated it is possible in genral to control spacecraft potential. PhysicalIy, neutralizer and eclipse events provide variable particle densities and current sources which have not yet been fully utilized in studying the interaction of the spacecraft with the environment.

2.0 INSTRUMENT

The instrument is described in detail in the Handbook which has been included as an appendix. Therefore only a brief description will be given here.

2.1 SCIENTIFIC OBJECTIVES

The primary objective of the UCSD particle experiment is to measure charged particle fluxes as a function of energy, direction and time. The charged particles measured consist of environmental electrons and ions and also particles emitted from the spacecraft such as photoelectrons, secondary electrons, and particles emitted by cesium ion accelration. The secondary objectives of the experiment are to use the measured particle fluxes to infer particle velocity distributions, spacecraft potential, the location and magnitude of differential charging on the spacecraft, and the magnitude and signs of the various charging currents to the spacecraft.

The particle data from the UCSD experiment, together with the data from the other experiments, provides a quantitative description of the charge state of the vehicle, and also a quantitative description of the environmental plasma, both as functions of time and therefore as functions of the satellite position in space. The ultimate aim of the experiment is twofold: to gain an understanding of the electrical charging and discharge processes of spacecraft; and to gain an understanding of the processes which control the environmental plasma.

The UCSD experiment (Figure 2.2-1 Appendix) has five electrostatic charged particle detectors. Two detectors (one for negative and one for positive particles) are contained in each rotating detector assembly (RDA). Each RDA can be rotated through a maximum of 220° about the

axis through the RDA cylindrical structure. The experiment is mounted on the outer edge of the top face of the EME package. The rotation of the RDA's can be stopped at any pre-selected position upon command. The limits of the range of rotation can also be selected by command so that the aseemblies can "wag" over small angular ranges if desired.

The detectors are capable of measuring particles with energies from a few eV up to 81 KeV. Each scan in energy consists of 64 energy steps spaced exponentially up to the maximum energy with an energy resolution $\Delta E/E$ at each step of approximately 20%.

2.2 MEASURING TECHNIQUE

Each of the five charged particle detectors is made from three subassemblies: An electrostatic curved plate energy/unit charge analyzer; an electrostatic grid structure which acts as a lens to focus those particles that have passed through the energy analyzer upon the sensor; and a Bendix Model 4213-PAC/WL spiraltron particle sensor with appropriate pulse electronics which counts the analyzed particles. Figure 2.2-2 shows a cross section of the detector assembly.

The curved analyzing plates are unique in that they are ovoidal, i.e., they have different curvatures in the parallel (energy analyzing) and perpendicular directions. In order to obtain azimuthal focusing (focusing in the perpendicular direction) for a spherical geometry, the particles must be bent 90°. In an attempt to maintain a large geometric factor the path length has been shortened such that the particles are bent 55°. The shorter radius of curvature in the azimuthal direction (26 percent shorter) results in a proper azimuthal focusing for the shorter path length. Also, the shorter azimuthal radius of curvature results in a neutral focusing in the parallel direction. The shorter path length and the postanalysis electrostatic lens for focusing the parallel direction maintain a large geometric factor (discussed below) and, in addition, good angular resolution. The angular resolution of each sensor is approximately 2.8° by 2.6° for a monoenergetic spectrum and 2.8° by 7° for a flat spectrum.

Figure 2.2-2 (view A-A) shows that the inside of the plates are serrated so that particles striking the sides will be eliminated resulting in a minimum of secondaries with forward momentum. The plates of the energy analyzer are driven by a power supply that can be programmed to supply any one of 64 voltage steps. These steps allow one to analyze particles of energy between less than 1 eV and 81 keV with an energy resolution of about (0.2E + 2) eV

full width at half maximum. The analyzer constant is approximately 11; thus several kilovolts must be applied to each plate in order to analyze particles in the higher energy ranges.

Another unique feature of the analyzers is the post-analysis electrostatic lens. This lens is a structure made of two wire grids positioned immediately after the energy analyzer. The first grid is held at the potential of the inner plate. The second grid is held at the potention to ground. A particle passing through this structure is strongly focused upon the center of the sensor. For the electron detectors, a cone has been mounted to control the electric field around the secondary particle suppressor (discussed below).

The geometric factor H (differential energy flux = count rate/H) which results from the inclusion of the lens is approximately 3.2 X 10^{-4} cm^2.sr for protons and 1.6 X 10^{-4} cm^2.sr for electrons.

The reason for the difference between these values is that because of higher expected electron fluxes, one-half of each electron aperture and one quarter of each ion aperture has been covered. The H factor is somewhat energy dependent at lower energies due to both a postanalysis acceleration which occurs at the spiraltron (°factor of 3 increase in H occurring gradually around 1 - 3 keV for protons and 0.1 - 0.3 keV for electrons). The fact that the electrostatic lens maintains a large geometric factor is very important. Such a geometric factor results in much higher counting rates than are normally available, yeilding better statistics. In addition, finer time resolution can be obtained since there is no need to reduce already low counting rates. Taking advantage of this feature, the detectors have modes which allow sampling up to 24 times a second in either electrons or ions.

A Bendix Model 4213-PAC/WL spiraltron particle sensor detects each charged particle which has passed through the energy analyzer. Pulse electronics attached to this sensor amplifies its output and sets a nominal dead time of 3.5 μs. This rate limiting rejects afterpulses and provides a stable well-known dead time so that true counting rates of 10^7 counts/s can be measured unambiguously. With the very large geometric factor, the lifetime of the spiraltron sensors is of paramount concern.

Suppression of secondary electrons and some additional focusing is accomplished by a semispherical suppressor shield which lies between the sensor and the electrostatic lens. The proton suppressor is at zero potential and the

electron suppressor is a 0 V for energy selection below 100 V and at -30 V for energy selection above 100 volts.

2.3 FUNCTIONS

The experiment was designed to allow a great deal of freedom in the programmed selection of energies. The simplest energy program available is called SCAN. In this program, the analyzer scans through the 64 discrete exponentially spaced energy levels. The program starts at the lowest energy and proceeds to the highest. Each energy level is maintained for 250ms before proceeding to the next energy level. After the 64th level, the cycle is repeated. One entire scan requires 16 s for completion. The more complicated energy selection program is called the SCAN-DWELL mode. This program starts with a single scan as described above. At the completion of the scan the analyzer jumps to a predetermined energy level (ED 1), one of the 64 scan energy levels, and maintains that energy level (DWELL) for a predetermined length of time (DT). At the completion of the dwell the analyzer performs a scan and then dwells at the next energy level (ED 1 + NEL) where NEL is the number of discrete energy levels between adjacent dwells of the same SCAN-DWELL program. This process continues until a predetermined number of dwells (ND) have occurred, at which time the program repeats. All of the abovew parameters (ED 1, DT, NEL, ND) are set by ground command.

The energy selection programs were designed to allow balance between obtaining full spectrum information and the monitoring of fast time variations at particular energies. The programmed dwells, for instance, are extremely useful in the study of Alfvén waves in the magnetosphere. When even higher time resolutions are required, ground commands can be sent which modify the accumulation of detector counts. There are six accumulator channels each of which gives one reading for each 0.25 s. Under normal accumulation, each of the four rotating detectors are simply gated to a single accumulator. The FDA is provided with two accumulator channels. It is possible to sample a detector at a higher rate than normally obtained by gating the output of the detector to more than one accumulator at the expense of information from some of the others. During the dwells it is possible to obtain up to 24 readings a second from one detector, subsequently increasing the time resolution of that detector.

Each of the RDA's is attached to the main housing by a shaft driven through worm gears by a stepping motor. The RDA's rotate at a rate of $60/43 \simeq 1.4^{\circ}$/s so that to complete the 220° forward and reverse cycle takes 314 s. The angle sweeping programs have been designed to allow

considerable freedom in the selection of angles. The RDA's can be parked in a number of preprogrammed positions. Also, the units can be rotated in a synchronous fashion or the east-west unit can be fixed while the north-south unit rotates. Finally, through real-time manipulation the RDA's can be parked at arbitrary angles of interest, for instance, the closest approach angel to the magnetic field.

2.4 OPERATIONAL ASPECTS

The normal mode of operation of the experiment is to rotate both RDA's through their full rotation angle while the analyzers scan sequentially through the 64 exponentially spaced energy levels. The program starts at the lowest energy level and proceeds to the highest energy level for each detector. The transition time between energy levels may be assumed to be negligible. This normal mode of operation is called the scan only mode in which the analyzer energy is controlled by consecutive scan programs.

Whenever the experiment is turned on it comes into the normal mode of operation unless additional commands are sent to command it into a special mode. Most special modes of operation will be chosen as part of the experiment operations plan. Special modes which will be frquently used involve restricting the angles of rotation of the RDA's to special angle intervals, or parking the RDA's at a certain fixed position. Other special modes will intersperse the energy scan program with dwell intervals when the analyzer energy is fixed for pre-determined periods by command.

3.0 DATA PRESENTATION

The usefulness of any scientific instrument is severely compromised if one does not have an adequate way to display the output. From the beginning of this program, we have tried to emphasize presenting the data in a form that makes it readily accessible and understandable to other workers so that they need not be intimately familiar with the instrument in order to use the data. We have tried to avoid generating large volumes of tabular hard copy. Our normal data presentation consists of two parts: line plots and spectrograms. This is a continuation of our policy developed with ATS-5. In fact, we have tried to make the forms of both the line plots and the spectrograms as similar to those of the ATS-5 output as possible in order to facilitate intercomparisons and as a service to those investigators who are already familiar with the ATS-5 formats.

3.1 MICROFILM LINE PLOTS

The raw data is plotted in 64 second segments every minute. This creates 2 second overlaps between frames and aides continuity. No editing or efficiency correction is done at this stage. This format is best for looking at rapid fluctuations or isolated events.

3.2 SPECTROGRAMS

As with the line plots, we have developed spectrograms which are similar in format to those of ATS-5. While spectrograms exist for most of the received data, special attention has been given to producing several types of spectrograms for the first forty days of operation. During this period, the whole instrument was operating perfectly. Shortly thereafter, the fixed ion detector failed, and the East-West detector suffered a partial failure which compromises about half of the data from it.

In addition to the standard types of spectrograms, we have also produced energy-angle spectrograms which help to visualize pitch angle distributions. For this type of presentation, the data is collapsed across a given interval of time in order to accumulate sufficient statistics.

As was the case with ATS-5, we intend to deposit the whole body of relevant spectrograms in the data center. At the present time, we are distributing them to interested parties upon request (see appendix A).

4.0 STUDIES

As can be seen from the references included in the appendix, much work has been generated by the ATS-6 data. These studies are continuing, and the consensus is that only the "cream" has been scraped from the top. Wave-particle interactions, plasma dynamics, global substorm response, and field line mapping are only a few of the active research. At UCSD, four graduate students are studying this data (another one recently graduated) and three senior scientists are also participating.

4.1 LOW ENERGY IONS

The Auroral Particles Instrument has been able to return information about the densities of very low energy ion populations at geosynchronous orbit. These results are frequently obscured by the normal effects of spacecraft charging. However, we have learned how to compensate for many of these effects, and continue the study.

4.2 SPACECRAFT INTERACTIONS

The addition of lower energy steps and the ability to

rotate with respect to the spacecraft body have enabled us to infer a great deal about the ways in which the spacecraft interacts with the natural plasmas. We have been able to trace certain classes of particle back to their origins on specific parts of the vehicle which are charged differentially with respect to spacecraft ground. In addition, we have carried out a successful program of using the on-board ion accelerator in both the normal and neutralized only modes to actively control the potentials.

The theory and understanding on the interactions of surface with particles and photons in space is still developing. The tests we have done on active control have been very important for the design of future systems.

4.3 PLASMA STUDIES

The studies of substorm dynamics that was started with ATS-5 has continued with the ATS-6 data. The addition of low energy measurements with pitch angle information has been important.

4.4 FIELD ALIGNED FLUXES

One of the outstanding features of this instrument has been its ability to sweep in angle and thus investigate the existance of intense field aligned fluxes of auroral energy particles. We have seen and reported both structural loss cones in the classic sense and "source" cones of excess particles coming from lower altitudes.

We have been unable to look in both directions along the field line simultaneously so we cannot unambiguously separate particle fluxes from field aligned currents.

4.5 CORRELATIVE STUDIES

Several possibilities for joint studies have been presented. We have continued our cooperation with S. Mende and R. Eather. They have installed scanning photometers and color television at the foot of the nominal field line of ATS-6 to obtain simultaneous observations. Data from two separate two week observing periods exist. We have already written a report on this study, but the work is continuing.

Another promising joint study is the comparison of ATS-5 and ATS-6 as they cross. Early in the mission, ATS-6 was stationed to the West of the ATS-5. Then it crossed over as it was moved to the Eastern location. Later it was returned to the Western site. Therefore we now have data for when the spacecraft were widely separated and for two crossings. One paper has been presented on these observations, but a student is currently working on

expanding the analysis. We hope to be able to study some PC4 events that occurred when the spacecraft were within a wavelength of each other.

4.6 THINGS LEFT TO DO

As has been indicated throughout this report, the ATS-6 Auroral Particles Instrument has already been responsible for many papers and talks. But several investigators from UCSD and many at other institutions are still actively working with the data.

The list of things that could still be done is quite comprehensive. It includes:

1. Electric Fields
2. Flows
3. Wave-particle Interactions
4. Magnetospheric Geometry
5. Spacecraft Interactions (Including Active Control)
6. Correlative Studies

We intend to continue working with the data on these problem areas.

APPENDIX A

REQUESTS FOR ATS-6 DATA

APPENDIX A

REQUESTS FOR ATS-6 DATA

1. Dr. S. I Akasofu
   Geophysical Institute
   C. T. Eluey Bldg.
   University of Alaska
   Fairbanks, Alaska 99701

2. Dr. G. A. Paulikas
   Space Sciences Lab
   The Aerospace Corp.
   P.O. Box 92957
   Los Angeles, CA 9009

3. Dr. George Parks
   Geophysics Program
   AK-50
   University of Washington
   Seattle, Washington 98195

4. Dr. Egbert Petelski
   Department of Plasma Physics
   Royal Institute of Technology
   Teknikringen 31-33
   S-100 44 Stockholm 70
   SWEDEN

5. Boston College

6. Dr. Ching Meng
   Space Sciences Lab
   University California Berkeley
   Berkeley, California 94720

7. Dr. George Gustafsson
   Kiruna Geophysical Institute
   S-981 01
   Kiruna 1
   SWEDEN

8. Dr. Ray Goldstein
   Mail Code 122-123
   Jet Propulsion Lab
   4800 Oak Grove Drive
   Pasadena, California 91103

9. Dr. Erlin Nielson
Max-Planck Institute
Postfach 20
D-3411 Katlinburg
Lindau 3, West Germany

10. Dr. Henry Garrett
PHF
Air Force Geophysics Lab
LG/Hanscom Air Force Base
Bedford, MASS 01730

11. Dr. John Foster
Aeronomy Center
Code UMC 41
Utah State University
Logan, Utah 84322

12. Dr. Robert Bartlett
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Goddard Space Flight Center
Greenbelt, Maryland 20771

13. Ms. Carolyn Purvis
Mail Code 54-3
Lewis National Research Center
2100 Brookpark Road
Cleveland, Ohio 44135

14. Dr. Herbert Cohen
LKK
Air Force Geophysics Lab
LG/Hanscom Air Force Base
Bedford, MASS 01730

15. Mr. Robert McInerney
Air Force Geophysics Lab (SVA)
Hanscom Air Force Base
Bedford, MASS 01730

16. Dr. Dave Hardy
PHF
Air Force Geophysics Lab
LG/Hanscom Air Force Base
Bedford, MASS 01730

17. Dr. Frederick Rich
Research Center
Regis College
Weston, MASS 02193

18. Dr. Jeffrey Hughes
Department of Physics
Imperial College of Science

and Technology
Prince Consort Road
London, England
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19. Dr. S. B. Mende
Lockheed Missiles and Space Company
Palo Alto Res. Lab
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Palo Alto, California 94304

20. Dr. James Sharber
PHF
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LG/Hanscom Air Force Base
Bedford, MASS 01730

21. Dr. Shen-Yi Su
C-23
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22. Dr. J. M. Penman
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23. Dr. John K. Hargreaves
Dept. of Environmental Sciences
University of Lancaster
Lancaster, England
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24. Dr. Kane

India

25. Dr. Margaret Kivelson
Earth and Space Sciences
University of California,
Los Angeles
Los Angeles, California 90024

26. Dr. Lother Rossberg
MPAC
Lindau, Germany

27. Dr. Barry Mauk
Geophysics Program
AK-50
University of Washington
Seattle, Washington 98195

APPENDIX B

RECENT PAPERS USING UCSD ATS-6 DATA

APPENDIX B

RECENT PAPERS USING UCSD ATS-6 DATA

The following is a list of our recent publications and papers.

ATS-6 UCSD Auroral Particles Experiment, B. H. Mauk, C. E. McIlwain, IEEE Trans. on Aerospace and Electronic Systems, AES-11, 6 Nov. 1976.

Operations of the ATS-6 Ion Engine and Plasma Bridge Neutralizer at Geosynchronous Altitude, R. C. Olsen, AIAA Symposium on Electric Propulsion, San Diego, April, 1978.

Active Modification of ATS-5 and ATS-6 Spacecraft Potentials, R. C. Olsen, E. C. Whiple, And C. K. Purvis, Symposium on the Effect of the Ionosphere on Space Systems and Communications, Washington, D.C., January, 1978.

Spacecraft Charging on ATS-6, B. Johnson, J. Quinn, and S. DeForest, Symposium on the Effect of the Ionosphere on Space Systems and Communications, Washington, D.C., January, 1978.

Plasma Clouds and Auroral Arcs, S. DeForest and R. Judge, ESRO Special Publication No. 107, 1974.

Spacecraft Charging Control Demonstration at Geosynchronous Altitude, R. C. Bartlett, S. E. DeForest, and R. Goldstein, AIAA 11th Electric Propulsion Conference Proceedings, New Orleans, La. March 19-21, 1975.

Auroral Electron Beams Near the Magnetic Equation, C. E. McIlwain, Physics of the Hot Plasma in the Magnetosphere, Proc. of Nobel Symposium, Hultqvist, B., and L. Stenflo, eds., Plenum Pub. Co., N.Y., 1975.

Observation of the Plasma Sheet During a Contracted Oval Substorm in a Prolonged Quiet Period, A. T. Y. Lui, S. I. Akasofu, E. W. Hones, Jr., S. J. Bame, and C. E. McIlwain, subm. J. Geophys. Res.

ATS-6 UCSD Auroral Particles Experiment, B. H. Mauk, and C. E. McIlwain, IEEE Transactions on Aerospace and Electronic Systems, vol. AES-11, 6, November 1975.

Observation of Photoelectrons and Secondary Electrons Reflected from a Potential Barrier in the Vicinity of ATS-6, E. C. Whipple, Jr., J. Geophys. Res. 81, 601, 1976.

Theory of the Spherically Symmetric Photoelectron Sheath: A Thick

Sheath Approximation and Comparison with the ATS-6 Observation of a Potential Barrier, E. C. Whipple, Jr., J. Geophys. Res. 81, 601, 1976.

The Signature of Parallel Fields in a Collisionless Plasma, E. C. Whipple, Jr., J. Geophys. Res. 82, 1525, 1977.

Modeling of Spacecraft Charging, E. C. Whipple, Jr., Proceedings of the AF/NASA Conference on Spacecraft Charging Technology, 1976.

The Plasma Environment at Geosynchronous Altitude, S. E. DeForest, Proceedings of the AF/NASA Conference on Spacecraft Charging Technology, 1976.

Active Control of Spacecraft Charging on ATS-5 and ATS-6, C. K. Purvis, R. C. Bartlett and S. E. DeForest, Proceedings of the AF/NASA Conference on Spacecraft Charging Technology, 1976.

Comment on Low Energy Electron Measurements in the Jovian Magnetosphere, R. J. L. Grard, S. E. DeForest, and E. C. Whipple, Jr., Geophys. Res. Letters, 4, 247, 1977.

Active Experiments in Modifying Spacecraft Potential: Results from ATS-5 and ATS-6, R. C. Olsen and E. C. Whipple, Jr., UCSD Report No. SP-77-01, May 1977.

Spacecraft Charging, S. E. DeForest, presented at Goddard Space Flight Center and at Air Force Geophysical Laboratory, 1977.

Presentations:

Magnetospheric Substorm Pitch Angle Distribution, B. H. Mauk, presented at 1975 Annual Sping Meeting of American Geophysical Union.

Active Control of Spacecraft Potentials at Geosynchronous Orbits, R. Goldstein, D. J. Fitzgerald, and S. E. DeForest, presented at 1975 Annual Spring Meeting of American Geophysical Union.

Observation of Photoelectrons and Secondary Electrons Reflected from a Potential Barrier in the Vicinity of ATS-6, E. C. Whipple, presented at 1975 Annual Spring Meeting of American Geophysical Union.

Substorm Induced Spacecraft Charging Currents from Field Aligned and Omnidirectional Particles, J. L. Vogl, N. L. Sanders, and S. E. DeForest, presented at 1975 Annual Spring Meeting of American Geophysical Union.

ATS-6 Observations of an Unusual Transient Change in the Ambient Particle Population Preceding a Substorm, A. Konradi, R. A. Fritz, A. J. Masley, B. H. Mauk, R. L. McPherron, G. A. Paulikas,

and R. J. Walker, presented at 1975 Annual Fall Meeting of the American Geophysical Union.

Evidence for Differential Charging of the ATS-6 Satellite, E. C. Whipple, Jr., presented at 1975 Annual Fall Meeting of American Geophysical Union.

Particle and Field Measurements of Standing ULF Waves at ATS-6, S. DeForest, W. D. Cummings, R. McPherron, presented at 1975 Annual Fall Meeting of American Geophysical Union.

Bouncing Cluster of Ions at Seven Earth Radii, C. E. McIlwain, presented at 1976 Annual Spring Meeting of American Geophysical Union.

On Inferring Parallel Electric Fields from Measured Particle Velocity Distributions, E. C. Whipple, Jr., Presented at Active Experiments in Space Plasmas, Boulder, Colorado, 1976.

Signature of Parallel Electric Fields in a Collisionless Plasma, E. C. Whipple, Jr., Presented at 1976 Annual Fall Meeting of American Geophysical Union.

Signature of Spacecraft Differential Charging Effects in Magnetospheric Particle Data, R. C. Olsen and E. C. Whipple, Jr., presented at 1976 Annual Fall Meeting of the American Geophysical Union.

A New Kinetic Approach to Magnetospheric Convection, E. C. Whipple, Jr., Presented at 1977 Annual Spring Meeting of American Geophysical Union.

Recent Oral Presentations Using UCSD ATS-6 DATA:

The following is a list of our presentations at international meetings.

Evidence for Differential Charging of the ATS-6 Satellite, Elden C. Whipple, Jr., presented at 1975 Fall Annual Meeting American Geophysical Union, San Francisco, Ca.

Particle and Field Measurements of Standing ULF Waves at ATS-6, Sherman E. DeForest, presented at 1975 Fall Annual Meeting American Geophysical Union, San Francisco, Ca.

Bouncing Clusters of Ions at Seven Earth Radii, Carl E. McIlwain, presented at 1976 Spring Annual Meeting of American Geophysical Union, Washington, D.C.

On Inferring Parallel Electric Fields from Measured Particle Velocity Distributions, Elden C. Whipple, Jr., presented at Active Experiments in Space Plasmas (cosponsored by COSPAR, URSI, and IAGA) Boulder, Colorado, June 1976.

Modelling of Spacecraft Charging, Elden C. Whipple, Jr., presented at Air Force/NASA Spacecraft Charging Technology Conference, A.F. Academy, Colorado Springs, Colorado, July 1976.

The Plasma Environment at Geosynchronous Altitude, Sherman DeForest, presented at Air Force/NASA Spacecraft Technology Conference, A.F. Academy, Colorado Springs, Colorado, July 1976.

Signature of Spacecraft Differential Charging Effects in Magnetospheric Particle Data, Chris Olsen and Elden C. Whipple, Jr., presented at American Geophysical Union Fall Annual Meeting, San Francisco, Ca., December 1976.

Signature of Parallel Electric Fields in a Collisionless Plasma, Elden C. Whipple, presented at American Geophysical Union Fall Annual Meeting, San Francisco, 1976.

Observation of a Traveling, Shear Alfvén Wave in the Dusk, Geosynchronous Magnetosphere with Amplitude Modulation by a PC-4 Oscillation Event, B. H. Mauk and R. L. McPherron, presented at American Geophysical Union Fall Annual Meeting, San Francisco, Ca., December 1976.

Modulation of Spacecraft Potential at the Ion Cyclotron Frequency, S. E. DeForest, M. H. Mauk, presented at American Geophysical Union Fall Annual Meeting, San Francisco, Ca., December 1976.

Alfvén Wave Observations and the Ion Cyclotron Instability in the Earth's Magnetosphere,' B. A. Mauk, C. E. McIlwain, R. L. McPherron, presented at Third International Congress on Waves and Instabilities in Plasma, Imprimerie de l'Ecole Polytechnique, Palaiseau, France, June 1977.

APPENDIX C

HANDBOOK FOR THE AURORAL PARTICLES EXPERIMENT

NOTE: Due to the limited supply we cannot furnish a handbook for each copy of this report. Selected figures are attached. Persons with a need for the entire handbookd are urged to request a copy.

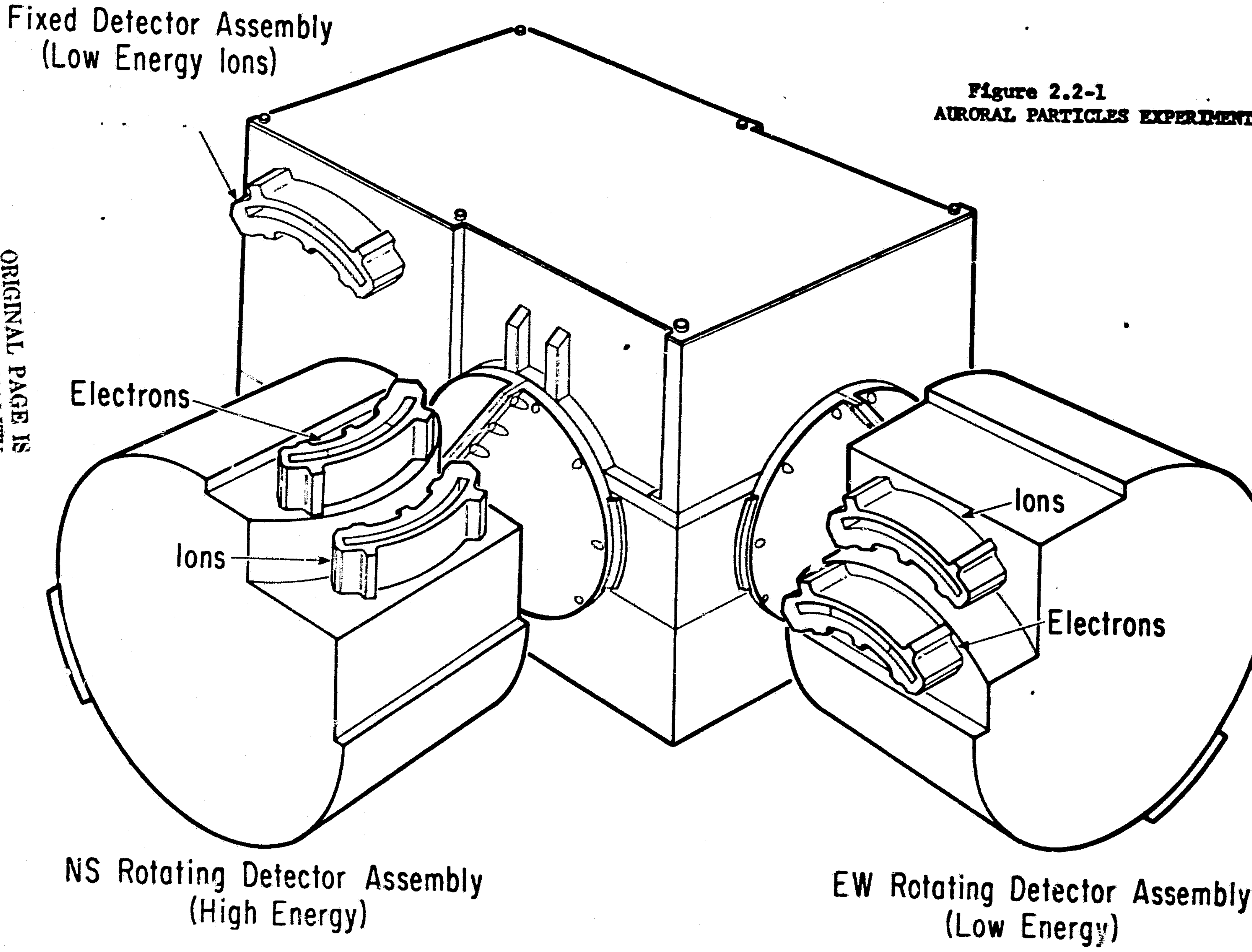

Figure 2.2-1
AURORAL PARTICLES EXPERIMENT

78EW-9 001A

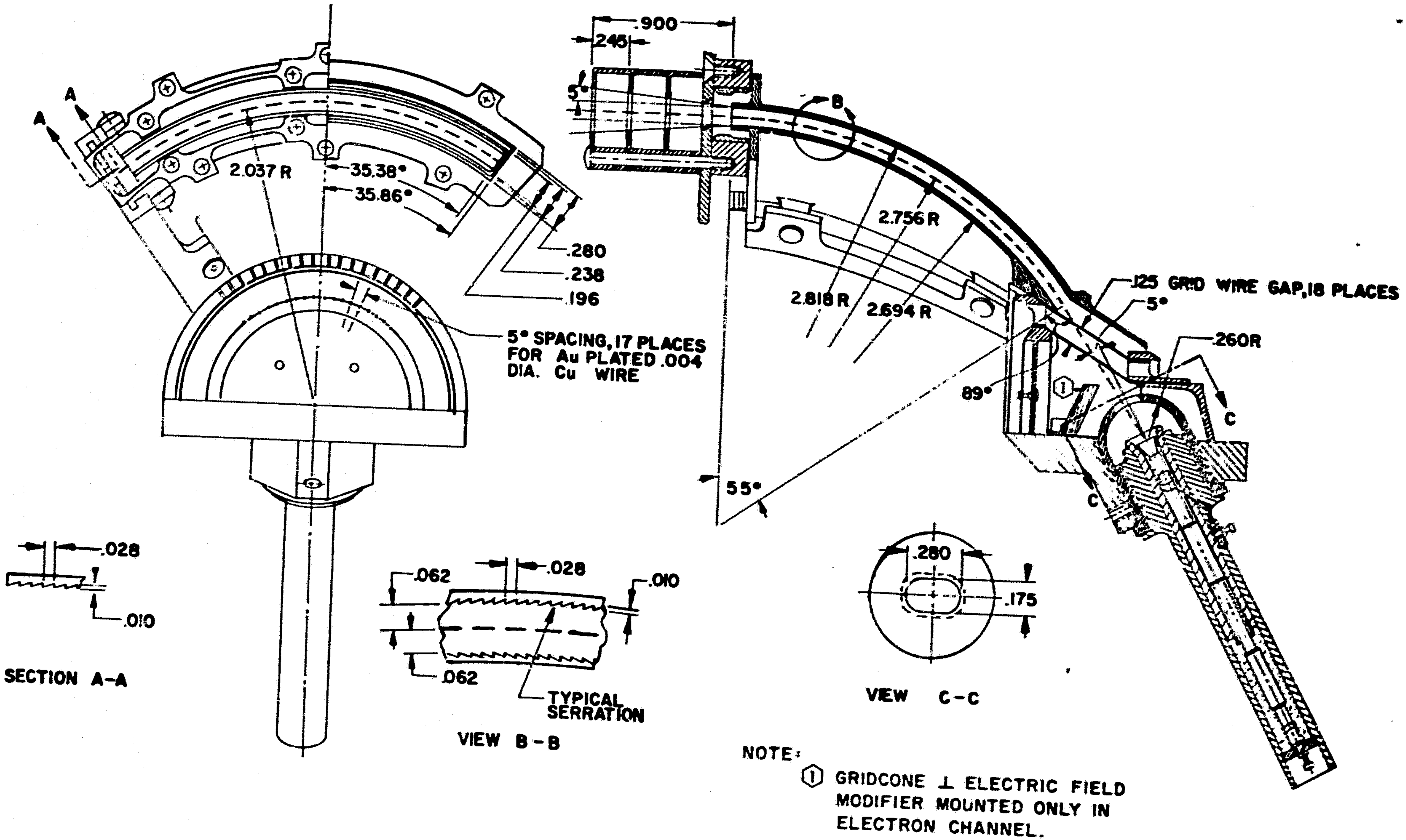

FIGURE 2.2-2

DETECTOR GEOMETRY

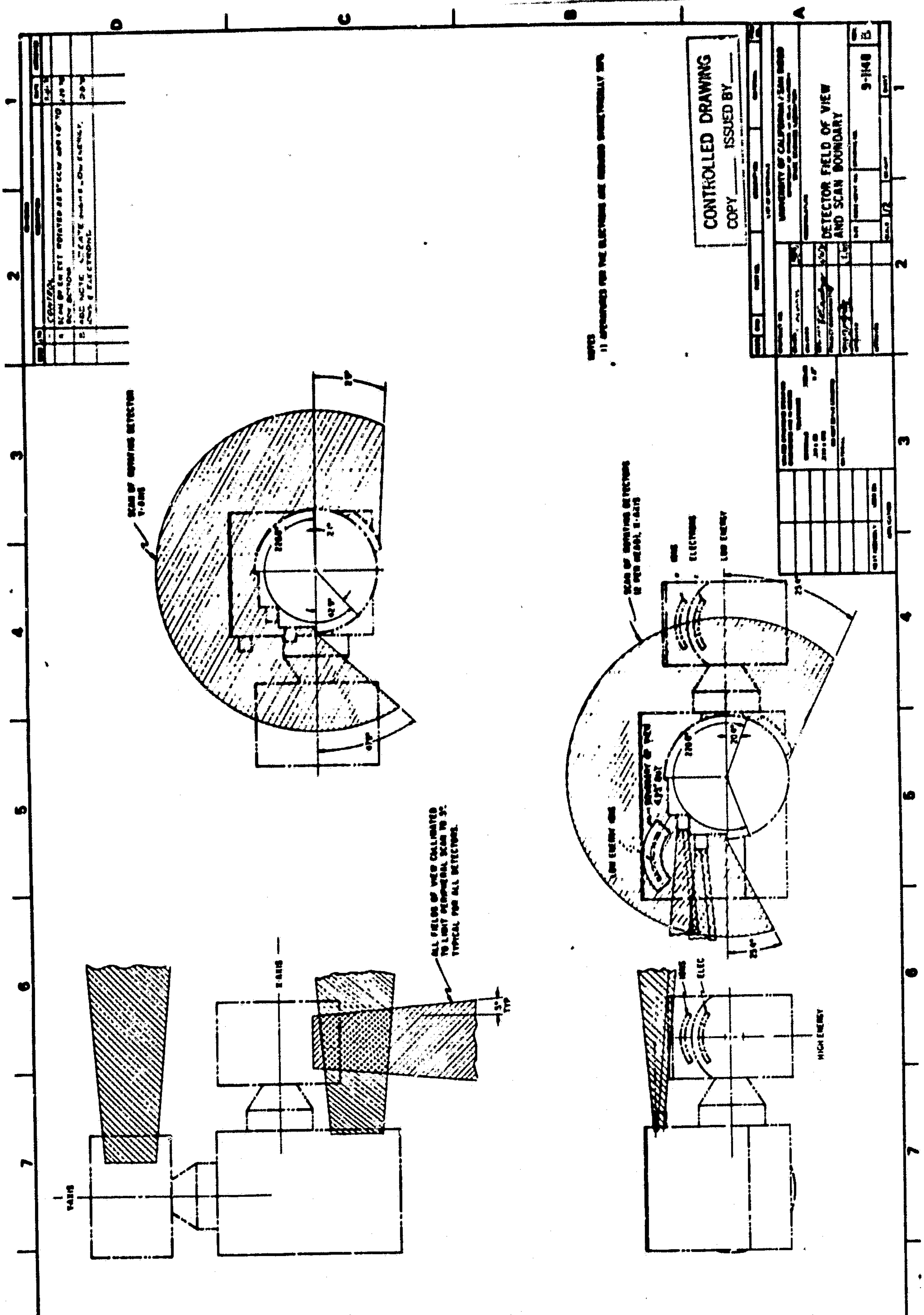

FIGURE 2.2-3

NOMINAL FIELD OF VIEW

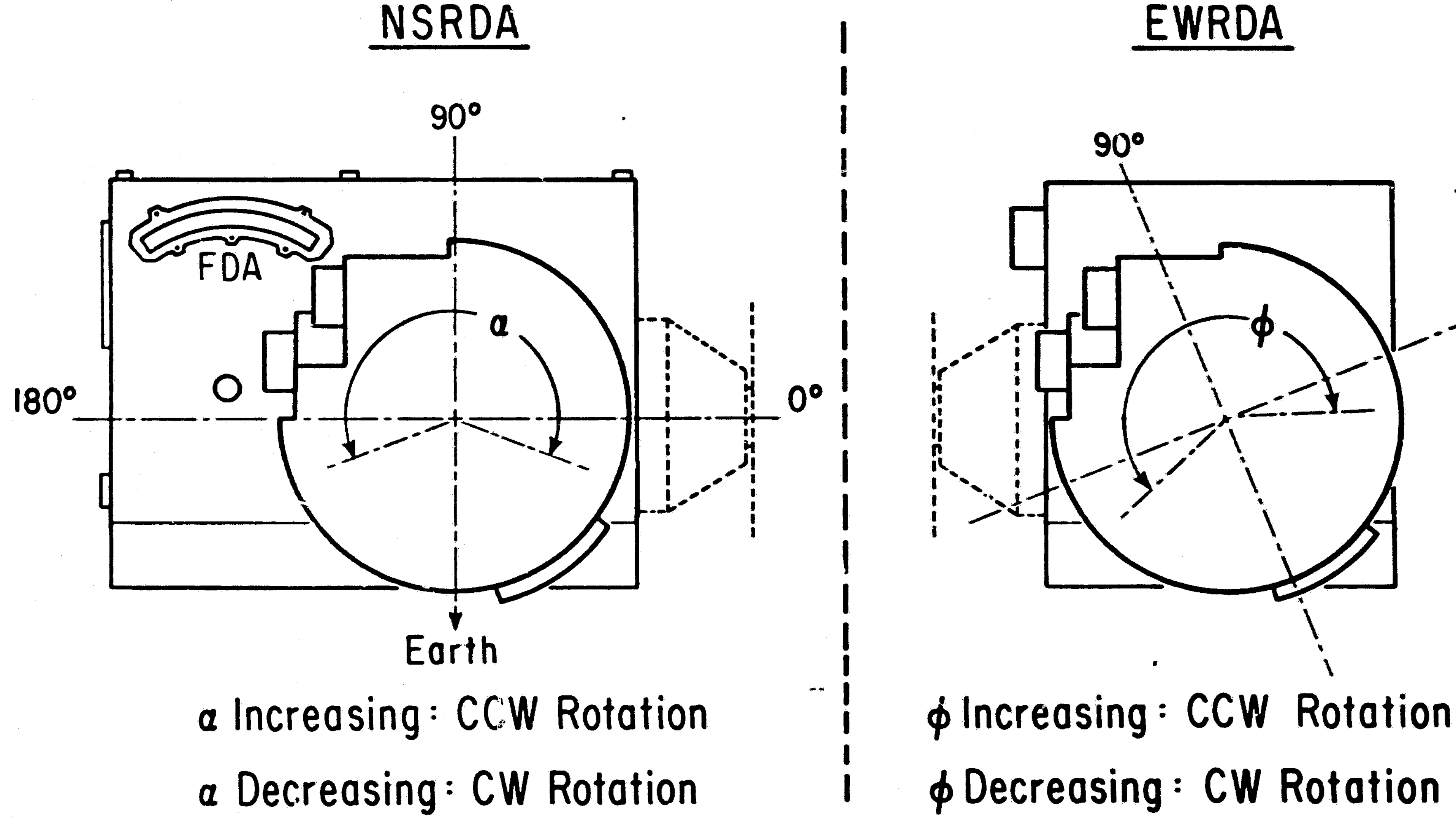

FIGURE 2.2.3-2
ANGLE DEFINITION

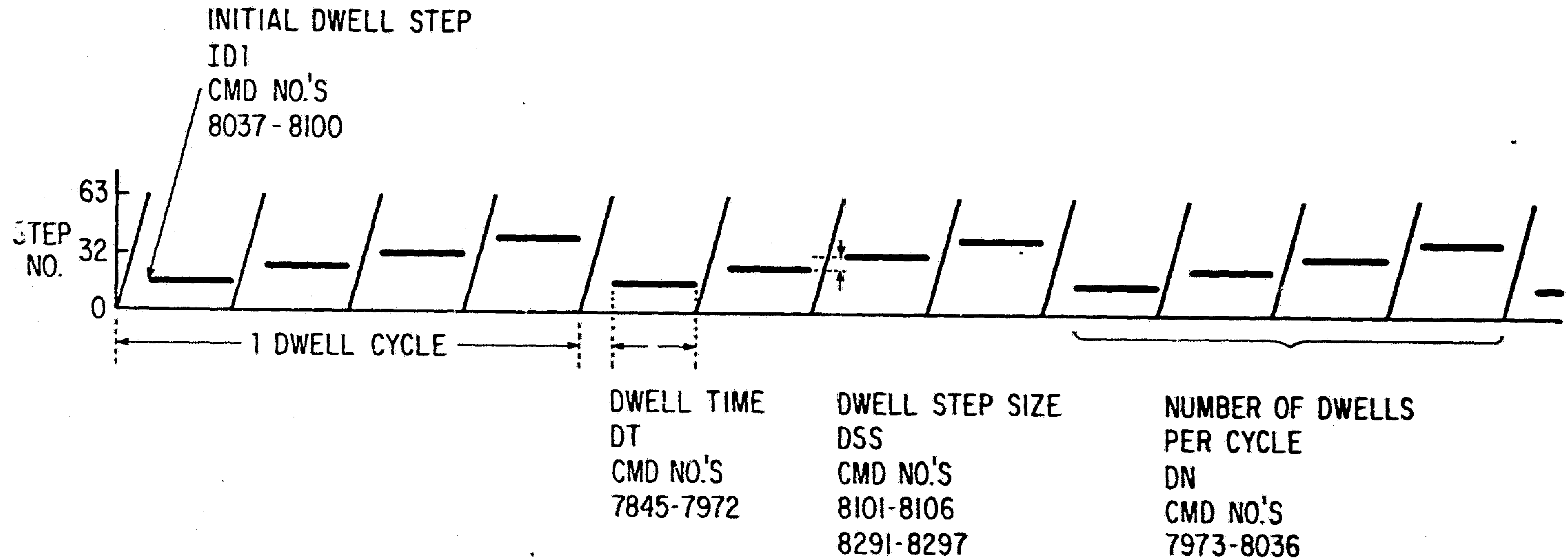

FIGURE 2.2.3-3

TYPICAL SCAN DWELL PROGRAM

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